WIRELESS INTRAOCULAR PRESSURE SENSOR (WIPS)

Interim or Final Report

JPL Task 1040

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A. OBJECTIVES

Glaucoma (Fig. 1) is a disease affecting millions of people in the US alone every year. Elevated intraocular pressure (IOP), the most common cause of glaucoma, slowly kills the optic nerve starting from the outside and progressing to the inside. Not surprisingly, this manifests itself at first in peripheral visual field loss. A novel computer-automated visual field test that is capable of detecting early glaucomatous visual-field loss has recently been developed jointly by Caltech and USC [1-6]. If untreated, glaucoma leads to blindness. In general, glaucomatous visual-field loss is considered irreversible. The usual treatment for glaucoma can be as simple as administering eye drops.

There are a number of external eye-pressure-measuring devices (e.g., Tono-pen) in existence. The problem with most of them is that they are fairly imprecise (e.g., dependent on corneal thickness and elasticity) and/or can only be administered at a doctor's office. For example, non-contact tonometry using pneumatic systems ("air-puff") is very dependent on the eye wall and corneal rigidity and can be grossly wrong because these factors are not taken into account. Therefore, systems based on non-contact tonometry are not good screening devices. All other technologies require touching something to the eyeball (i.e., cornea) and thus can only be done in an ophthalmologist's or optometrist's office.

More realistic IOP measurements can be obtained from within the eye. A variety of devices for this purpose have been proposed or developed in the recent past [7-13]. However, none of the micromachined devices are being used as a standard method to measure IOP because they are too invasive to be implanted and/or have not been validated in a realistic variable-pressure environment (e.g., animal eye).

It is known that the IOP within the same eye of a person undergoes drastic changes (oscillations) during the 24 hours in a day (Fig. 2); thus a pressure measurement at a doctor's office can at best only get a snapshot in time of the currently prevailing intraocular pressure, missing all the other oscillations. Consequently a sporadic IOP measurement may still not prevent glaucomatous damage from happening.

A self-checking non-contact IOP-monitoring system with daily readout that measures the true intraocular pressure is very important and much needed. Beyond the screening for high IOP, there are issues related to drug therapy for glaucoma and how to titrate and monitor these treatments: While on therapeutic eye drops, one often sees salient and transient periods of breakthrough elevation of the IOP which can damage the eye. Therefore we would like our proposed wireless intraocular-pressure sensor (WIPS) to red-flag even one such violation. This close monitoring of the IOP would greatly help the control and optimization of glaucoma drug therapy, especially for patients who already have the diagnosis of glaucoma.

From a JPL-NASA point of view, the proposal addresses an important aspect of human space flight: According to the Space Medicine Office at NASA's Johnson Space Center, intraocular hypertension and intracranial hypertension due to microgravity are known problems in the operative environment of space flight. Thus, monitoring IOP is essential for long-duration space missions, and enhances the chances for timely countermeasures before astronaut performance is impaired or permanent damage encountered.

Our proposed goal is to develop, as a first step, a prototype of a pressure sensor that in the end would be accurate and small enough to be implantable in the eye, to monitor the intraocular pressure continuously or on demand.

B. PROGRESS AND RESULTS

Goals of DRDF proposal accomplished:

- Creation of a Breadboard test bed (Fig. 3)
- Creation of a Breadboard design (non-implantable, Fig. 4) consisting of a commercial-off-the-shelf (COTS) pressure sensor and a low-power and wireless readout circuit for measuring the intraocular pressure
- Creation of a Brassboard test bed (Fig. 5)
- Creation of a Brassboard design (non-implantable, Fig. 6) consisting of a COTS pressure sensor and an integrated low-power and wireless readout circuit
- Several alternative/additional circuit designs have been investigated.

C. SIGNIFICANCE OF RESULTS

This task developed the foundation for an implantable wireless intraocular-pressure-sensing device and paved the way for the future development of an implantable intraocular-pressure controller that would automatically control the IOP and keep it below a preset level at all times, thus preventing the onset or progression of glaucoma.

D. FINANCIAL STATUS

The total funding for this task was $50,000 all of which has been expended.

E. PERSONNEL

No other personnel were involved.

F. PUBLICATIONS and PRESENTATIONS

[1] W Fink et al., "Wireless Intraocular Pressure Sensor", *The NASA Medical Technology Summit*, February 11-13, 2003, Pasadena, California

[2] W Fink et al., "Eye Sensors and Vision Tests in Space", *NASA BioE/Biotech Conference*, June17-18, 2003, NASA Johnson Space Center, Houston, Texas

G. REFERENCES

[1] Fink W, Sadun AA (2002), "Novel 3D computer-automated threshold Amsler grid test", abstract, lecture, proceedings, *IPS-Meeting 2002 (International Perimetric Society)*, Stratford-Upon-Avon, UK

[2] Fahimi A, Sadun AA, Fink W (2001), "Computer automated 3D visual field testing of scotomas in glaucoma", abstract, poster, *ARVO 2001 (Association for Research in Vision and Ophthalmology)*, Fort Lauderdale, Florida, IOVS 42 (4) 149

[3] Nazemi PP, Fink W, Sadun AA, Minckler D, Francis B (2001), "Early detection of glaucoma by means of a novel computer-automated 3-D visual field test", abstract, poster, *AAO 2001 (American Academy of Ophthalmology)*, New Orleans, Louisiana, Proceedings 159

[4] W Fink, AA Sadun, JB Clark, "Worldwide Accessible Comprehensive Visual Field Test & Diagnosis System", *ARVO 2003 (Association for Research in Vision and Ophthalmology)*, Fort Lauderdale, Florida, abstract and poster.

[5] W Fink W, AA Sadun, "Novel 3D Computerised Threshold Amsler Grid Test", *Perimetry Update 2002/2003 (in press)*, Proceedings of the XVth International Perimetric Society Meeting in Stratford Upon Avon, England, June, 2002, Wall M, Henson D, Eds., Kugler Publications bv, Amsterdam/New York.

[6] W Fink, AA Sadun, "3D Computer-automated Threshold Amsler Grid Test", *Journal of Biomedical Optics (in press)*.

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[11] E.-C. Park et al, “Hermetically sealed inductor-capacitor resonator for remote pressure monitoring”, *Jpn. J. Appl. Phys.* Vol. 37 (1998) pp. 7124-7128.

[12] R. Puers et al, “Electrodeposited copper inductors for intraocular pressure telemetry”, *J. Micromech. Microeng.*, vol. 10 (2000) pp. 124-129.

[13] M. L. Manwaring et al, “Remote monitoring of intracranial pressure”, *annals of academy of studenica* vol. 4 (2001) pp. 77-80.

H. APPENDIX: *SUPPORTING FIGURES*

Fig. 1:

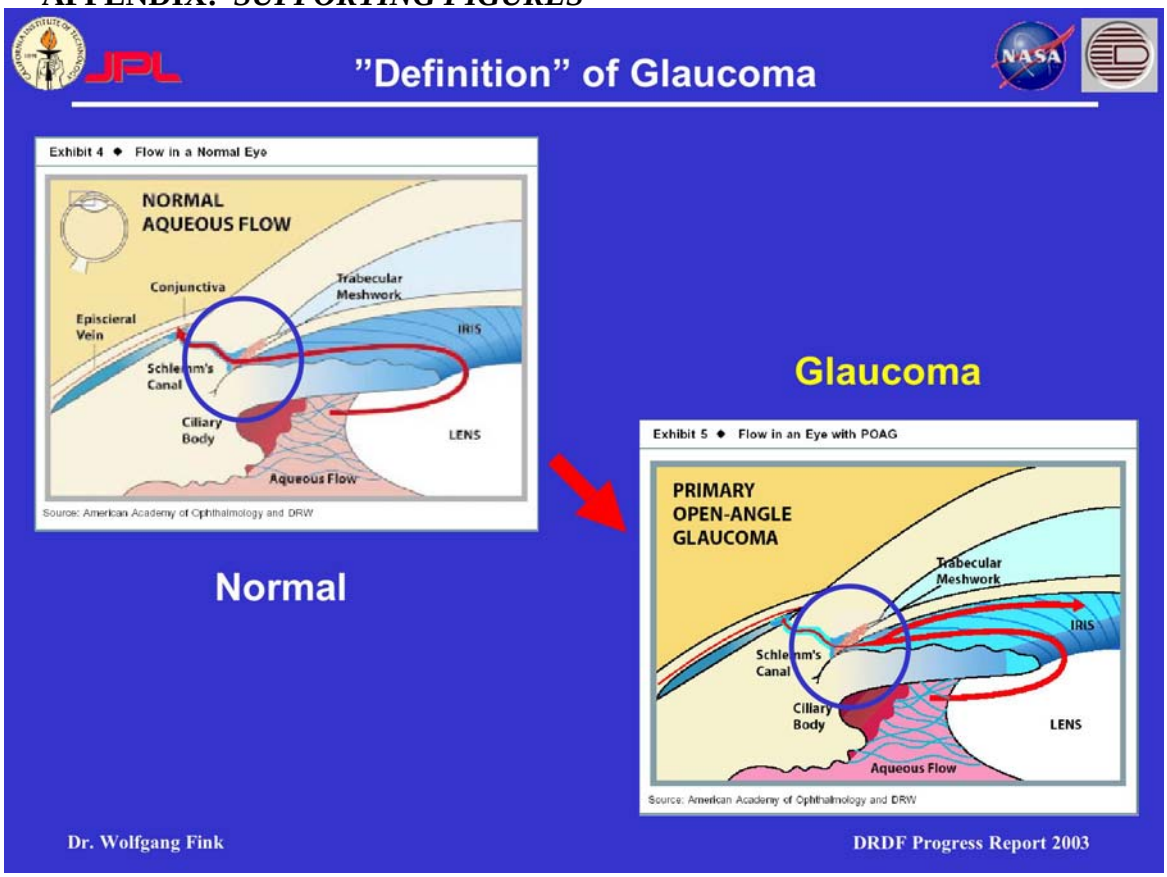

Fig. 2:

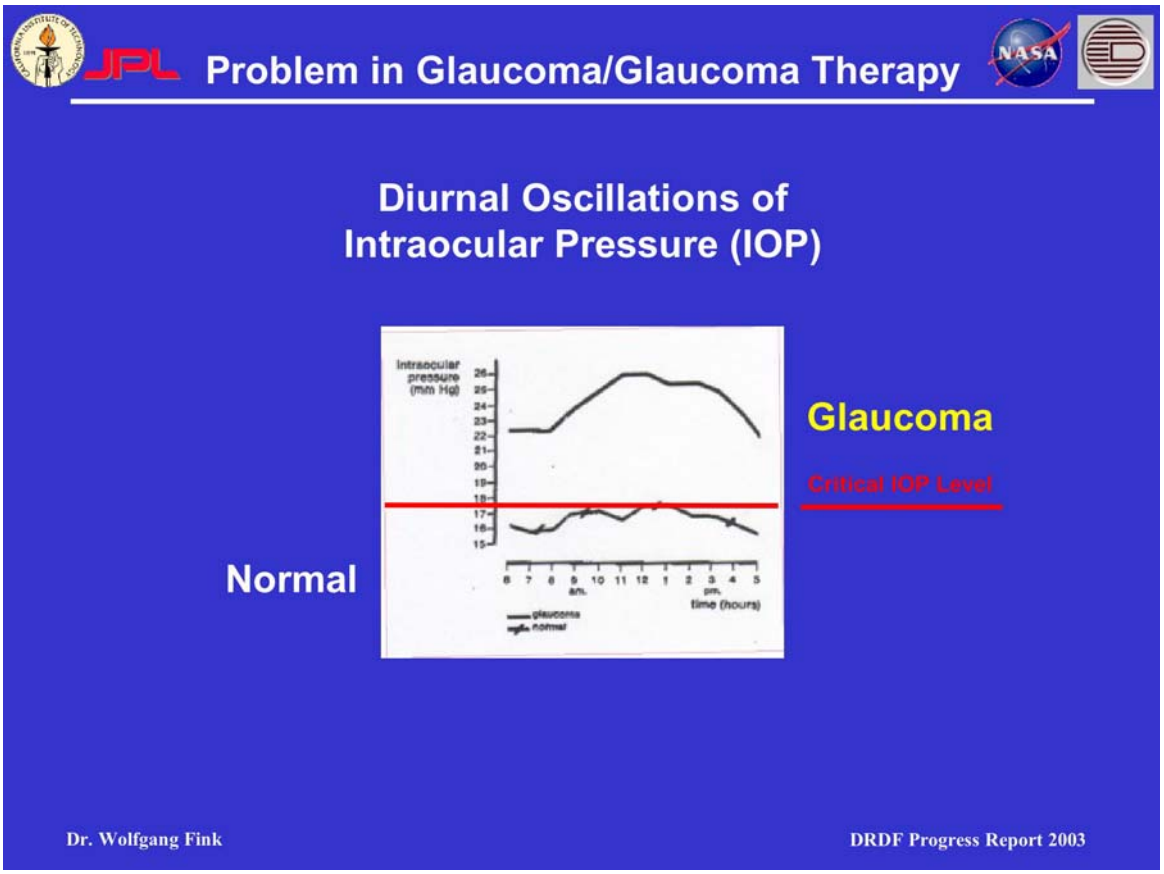

Fig. 3:

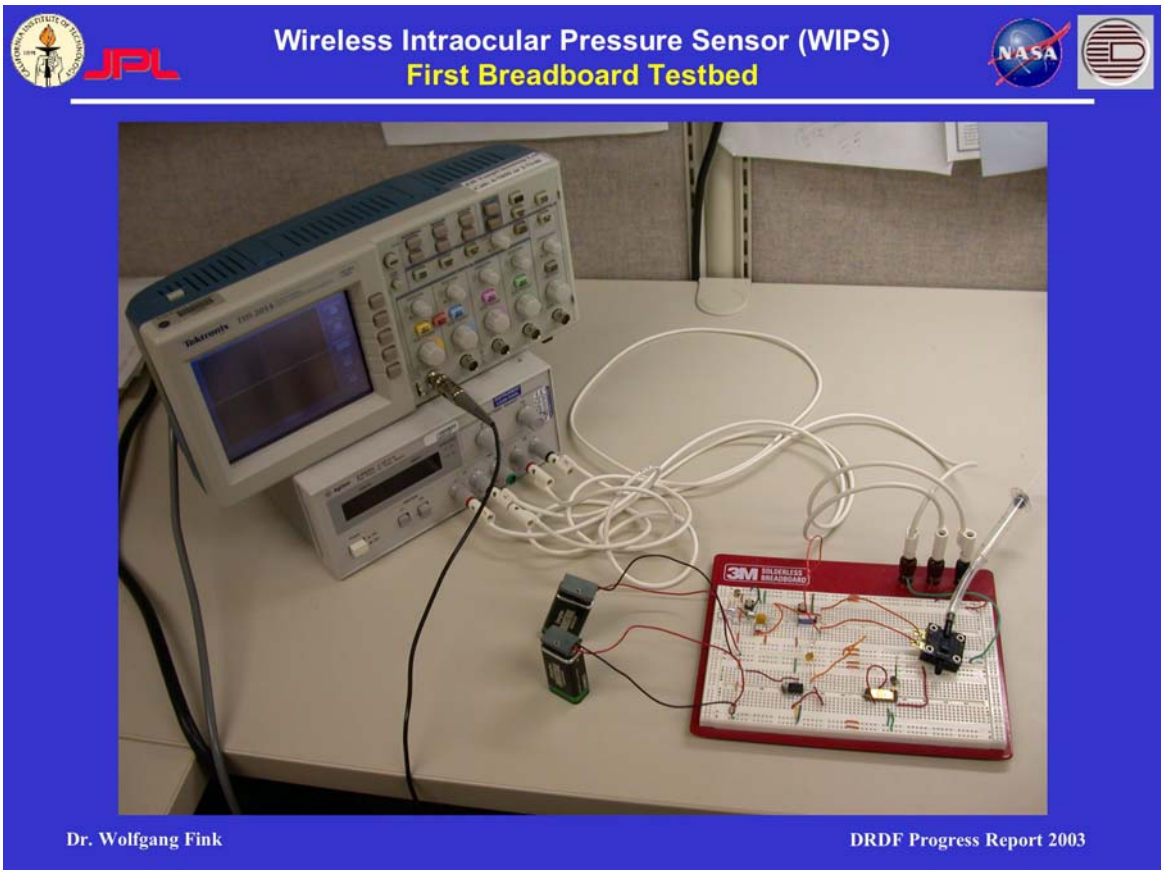
Wireless Intraocular Pressure Sensor (WIPS)
First Breadboard Testbed
JPL
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Fig. 4:

Wireless Intraocular Pressure Sensor (WIPS)
First Breadboard Design
JPL
NASA
3M SOLDERLESS BREADBOARD
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Fig. 5:

Wireless Intraocular Pressure Sensor (WIPS)
Current Brassboard Testbed
JPL
NASA
MAGNEHELIC
Dr. Wolfgang Fink
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Fig. 6:

Wireless Intraocular Pressure Sensor (WIPS)
Current Brassboard Design
JPL
NASA
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